

State of Evidence for Seepage from Oil Sands Tailings Ponds to Natural Waters

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Disclaimers

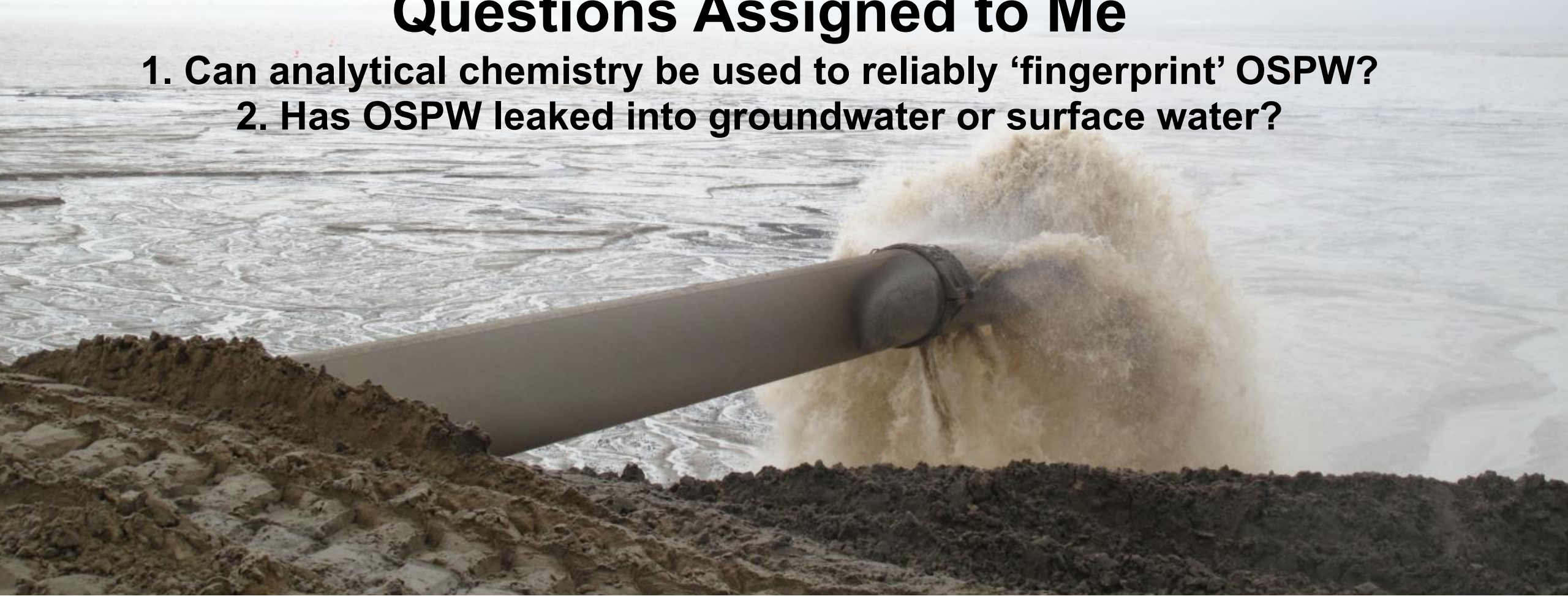
- My review and opinions expressed in the factual record are based on literature available by February 2019.
 - My report was submitted April 2019.
- I was given a list of scientific papers to include but was also free to explore any literature I thought was relevant.
 - Mainly peer-reviewed sources, but also included government reports and academic theses.

Oil Sands Process-Affected Water (OSPW)

- contains the water soluble fraction of bitumen, a complex mixture
- toxic to aquatic organisms, primarily due to 'naphthenic acids' (NAs)
- environmentally persistent, half-life on order of decades

Questions Assigned to Me

1. Can analytical chemistry be used to reliably 'fingerprint' OSPW?
2. Has OSPW leaked into groundwater or surface water?



Question 1

**Can analytical chemistry be used to reliably
'fingerprint' OSPW?**

Challenge 1: Bitumen-Impacted Water is Also Natural in the Region

Typical tailings pond OSPW has **20 mg/L NAs**

Sun et al. (2017) reported **2 mg/L NAs** in natural groundwater upwelling into the AR River, and **0.034 mg/L** in natural tributary river (Pierre River).

The NA fingerprints can look similar in OSPW and natural sources, and substantial variability within ponds, between ponds, and between natural sites

Analytical Fingerprinting - OSPW vs Natural

- See p.133 of Factual Record for full summary
 - **Mass spectrometry**, spectral, organic & inorganic geochemical methods
- *“No individual mass spectrometry analytical method available today can be used to confidently assign the source of bitumen derived organics in water...”*,
 - But “when used in combination with other geochemical analyses, or when applied to strategic sample sets, the overall body of evidence would be strong enough to make such an assessment”
- Important not only to consider analytical chemistry but also to have **knowledge of the hydrological system** where samples are taken, **historic measurements**, and **spatial trends**.
- **It’s not just about good analytical methods, it’s about study design, knowledge, and interpretation with awareness of limitations**

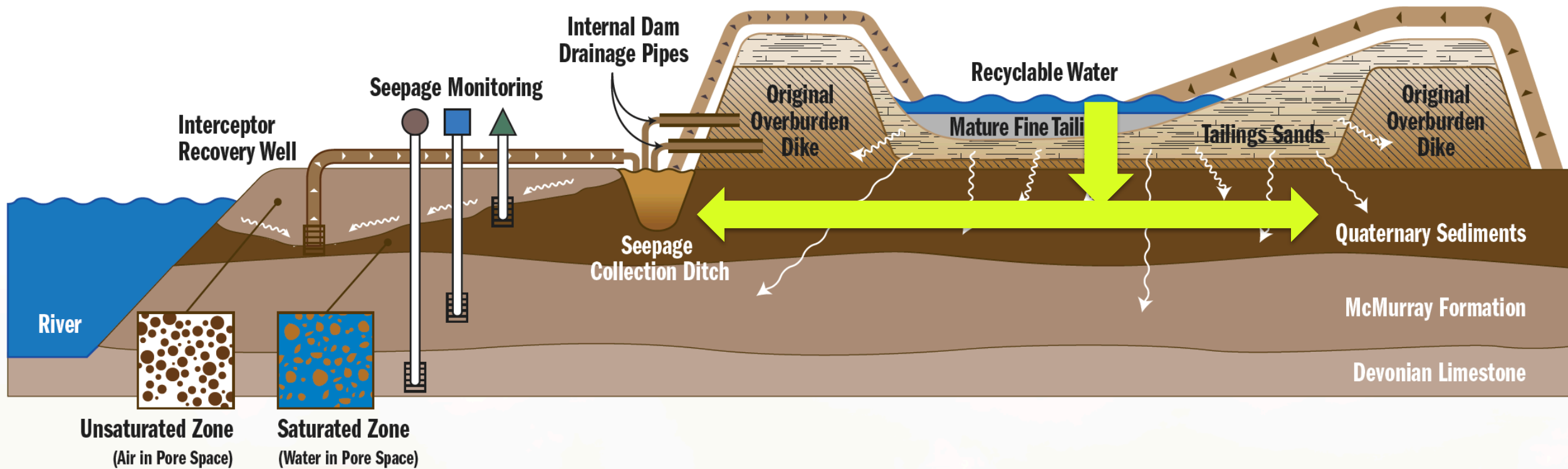
Question 2, Part A

Has OSPW leaked into groundwater?

Tailings ponds have contaminated groundwater

- *“There is strong evidence of OSPW seepage into near-field groundwater around tailings ponds, and has been since the first peer-reviewed evidence was published in 2009.”*
 - Even with imperfect analytical methods, critical evidence include:
 - Spatial trends showing declining chemical signatures as one moves away from tailings ponds
 - Detection of a signal at a location where there was not a signal before
 - Field-scale experiments

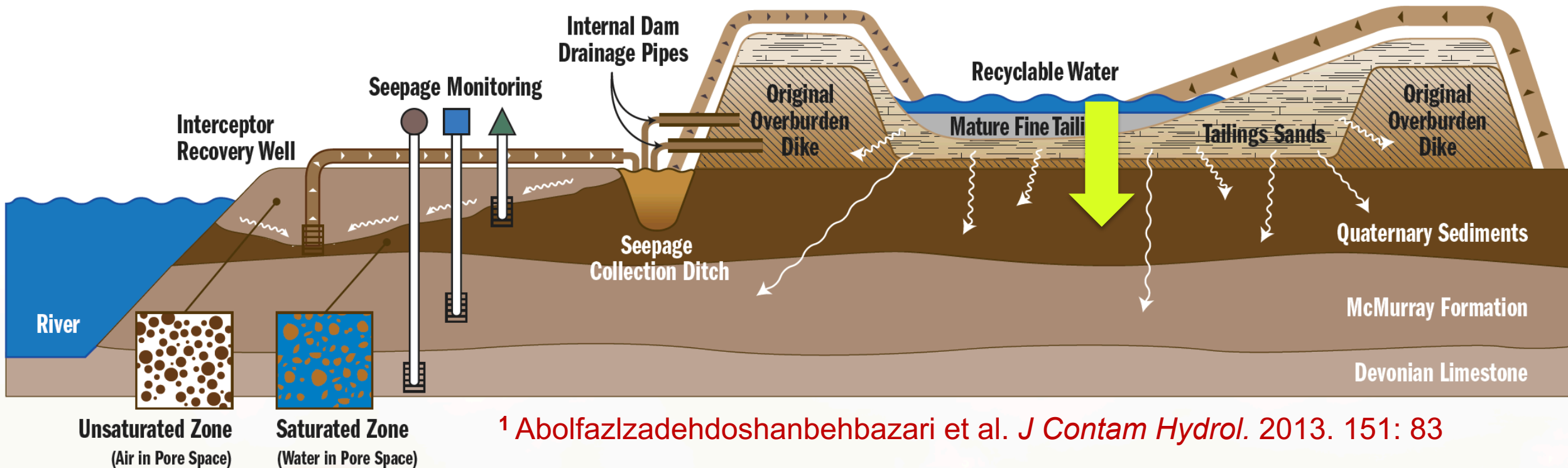
“Although tailings ponds have seepage water collection systems which capture seepage coming horizontally through the walls of the structure, there is both experimental and monitoring evidence for a slow vertical seepage pathway that may circumvent these collection systems and contaminate aquifers.”



Slow 'Vertical Seepage' Can Occur...

- Experimental evidence

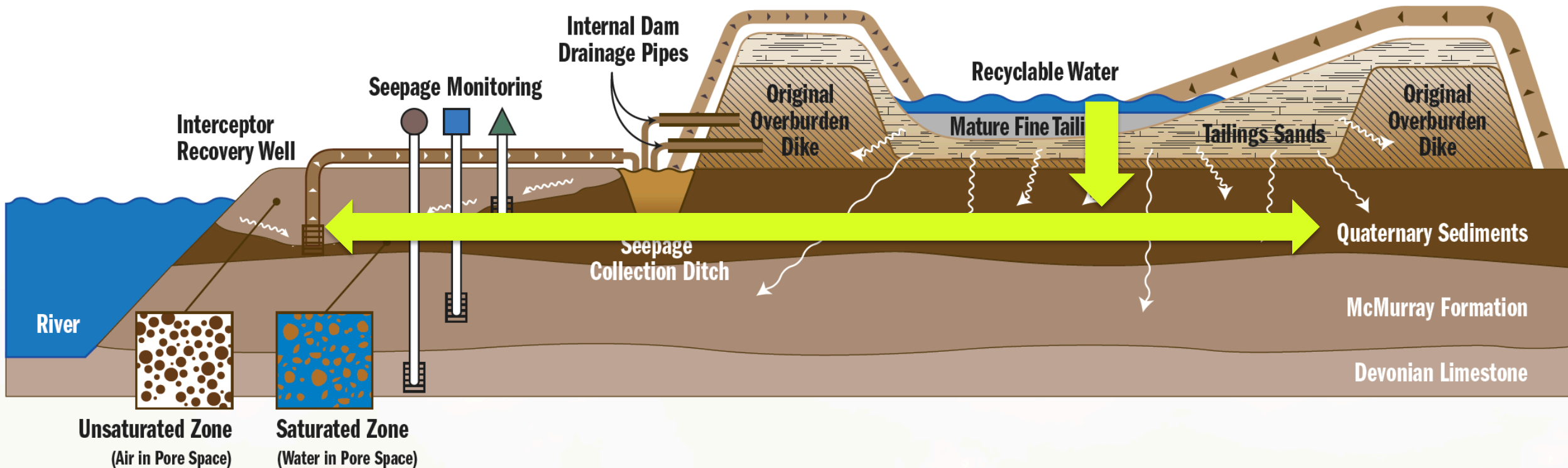
- 10x10m test pond adjacent to *South Tailings Pond*, vertical migration of OSPW 90 cm in 2 yrs into clay till.¹



¹ Abolfazlzadehdoshanbehbazari et al. *J Contam Hydrol.* 2013. 151: 83

OSPW detected outside tailings ponds

- Clear signals of OSPW in monitoring and interceptor wells
- Mildred Lake Settling Basin, Muskeg River Mine, Suncor Pond 1



Summary of Evidence at 3 Tailings Ponds:

- **Mildred Lake Settling Basin**, up to 900 m by 2005,¹ and up to 2 km by 2011²
 - **gradual decline** of Cl⁻, Na⁺,¹ stable isotope signatures, organic acids (Orbitrap) by high-res mass spectrometry)²
 - **site history** indicating no previous traces of bitumen-derived organics in the same aquifer, the tailings pond was the only possible source.
- **Muskeg River Mine**, seepage beyond the seepage ditch (<300m) by 2010.⁴
 - **Declining trends** moving away from the pond/ditch, including organic acids, major ions, pH, and stable isotopes. Non-detect outside the outer ditch.
- **Pond 1**, OSPW detected in monitoring and interceptor wells located just above the river³
 - Combined chemical evidence from 2 (3) peer-review studies **in monitoring/interceptor wells**. The dyke of this pond is in the river, making spatial studies difficult.

¹ Oiffer et al. *Journal of Contaminant Hydrology*, 2009. 108: p.89

² Ahad et al. *Environ Sci Technol*, 2013. 47: p.5023

³ Frank et al. *Environ Sci Technol*, 2014. 48: p.2660

⁴ Yasuda et al. *Canadian Geotechnical Journal*, 2010. 47: p.1305

Question 2, Part B

Has OSPW leaked into surface water?

Challenge 2: Dilution in Large River

Athabasca River = 177-4700 m³/s

11 Million L/d = 0.13 m³/s

“In systematic surveys of the mainstem Athabasca River with the best available analytical methods... there is no evidence of dissolved bitumen-derived organics (natural or anthropogenic) being detectable in any water samples.”

Factual Record

11 MILLION LITRES A DAY

**THE TAR SANDS'
LEAKING LEGACY**



DECEMBER 2008

ENVIRONMENTAL DEFENCE



Former 'Pond 1'

'Tar Island Dyke'

Monitoring Well

Interceptor well

Drivepoint water samples

'Likely OSPW-Affected'
Frank et al 2014, Roy et al. 2016

Is OSPW entering the River?

●● Locations of wells and drivepoints are approx. (from Frank et al. 2014)

Photo: Edmonton Journal

New Study, January 2020

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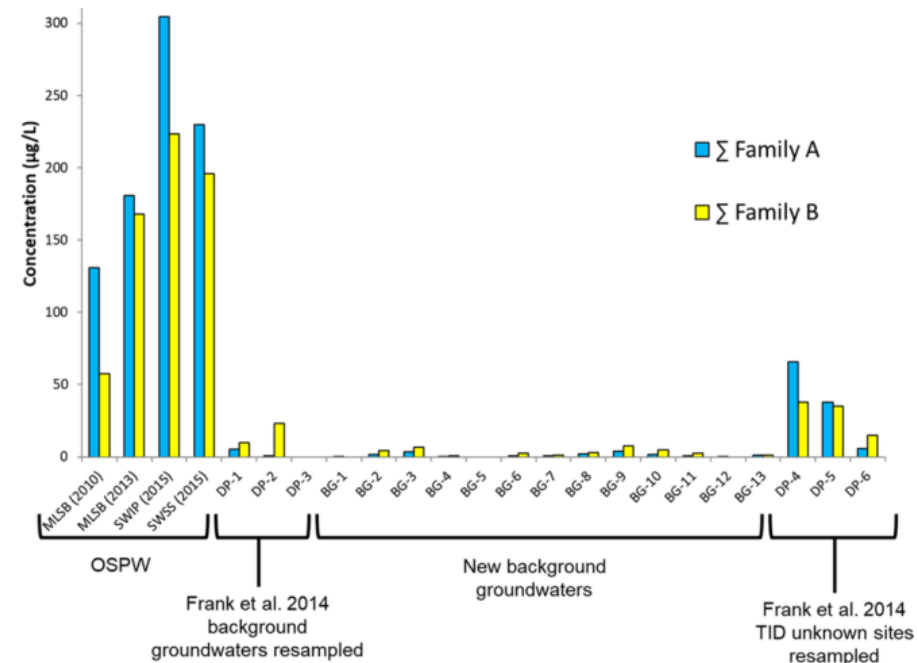
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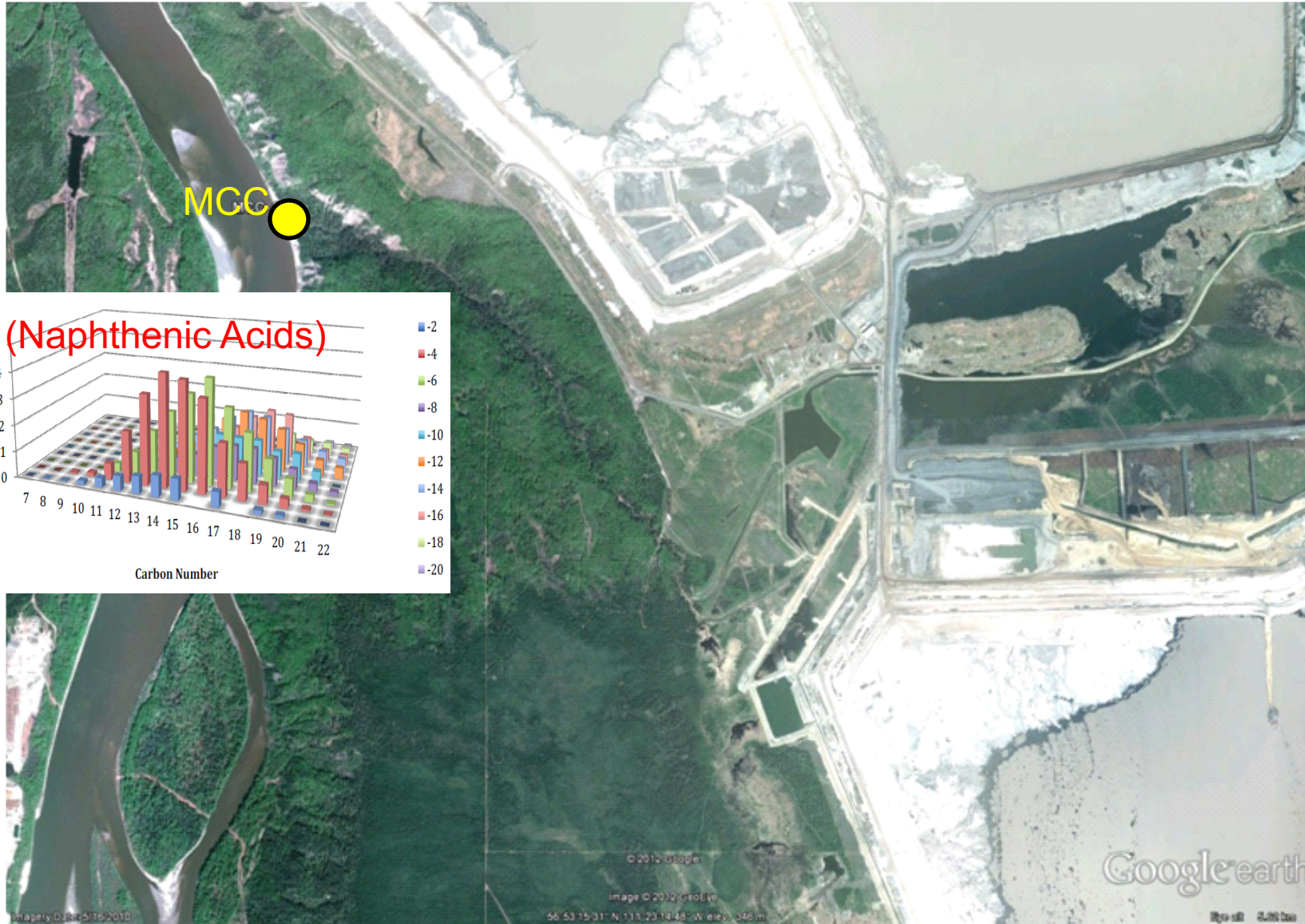
Advances in Distinguishing Groundwater Influenced by Oil Sands Process-Affected Water (OSPW) from Natural Bitumen-Influenced Groundwaters

L. Mark Hewitt,* James W. Roy, Steve J. Rowland, Greg Bickerton, Amila DeSilva, John V. Headley, Craig B. Milestone, Alan G. Scarlett, Susan Brown, Christine Spencer, Charles E. West, Kerry M. Peru, Lee Grapentine, Jason M.E. Ahad, Hooshang Pakdel, and Richard A. Frank



- *“This study supports the conclusions of Frank et al. (2014) that groundwater affected by OSPW is reaching the Athabasca River system beside Tar Island Dyke at a few locations. The ecological implications of this, if any, are not immediately apparent.”*

McLean Creek, an OSPW-impacted tributary?



- Lower McLean Creek (MCC) known by industry to be a 'possible site' of OSPW seepage
 - Ref 60, Factual Record
- Interception pumping wells installed in 2006 to mitigate future risk of South Tailings Pond.
- Highest concentrations of NAs among any surface water analyzed by Ross et al. in 2011 (**81 ug/L**) and was also elevated in the study of Sun et al. in 2015 (**30.1 ug/L**).

Beaver River, an OSPW-impacted tributary?

- Beaver River is known to have historically received seepage and runoff from nearby Syncrude Mildred Lake Settling Basin according to a 2008 report.

Golder Associates, FINAL REPORT. BEAVER CREEK PROFILING PROGRAM. 2008 FIELD STUDY. Submitted to: Syncrude Canada Ltd. Fort McMurray, Alberta. 2009.

- Dams constructed in 1999-2000 to control runoff and seepage, but the report notes OSPW nevertheless detected below the lower dam, leading to upgrades of the dam in 2004.
- NAs measured in Beaver River by Ross et al. in 2011 were 10.9 ug/L, while Sun et al. detected 190 µg/L NAs in 2015.
- **Future need:** high spatial-resolution and more frequent coordinated studies of these potentially impacted tributaries, including parallel samples of monitoring wells in the vicinity.

Summary

- A mechanism for vertical seepage of OSPW that can bypass containment is demonstrable (experimental and observational evidence), in particular at the oldest tailings ponds.
 - Pond 1, recent Federal studies together support seepage of OSPW-impacted water into the Athabasca River.
 - At other known seepage sites, distance from river gives opportunity to intercept
 - Seepage at many other tailings ponds (16 others) and Base-Mine Lake not evaluated in peer-review
- Industry reports indicate key tributaries impacted by OSPW in past, or which are sites of concern.
 - Two such sites have consistently contained OSPW-like NAs in academic studies, and should be a focus in future, in addition to other major tributaries

